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THE EFFORT TO MAKE ALGEBRA YIELD FRUIT.

By W. A. Cornish.

There is a great searching of heart among the teachers of algebra. The idea is abroad that algebra is the barren fig tree. Our association has a committee at work revising the old or devising a new algebra syllabus. Only about a year ago the Central Association published the report of its committee on algebra in the secondary schools, which report constitutes an algebra syllabus with many suggestions as to method of treatment.

Only a few years ago the American Mathematical Society put out a new syllabus. Various other associations of teachers and scientists up and down the world have within a few years put forth new schemes both as to subject matter and method of teaching algebra. This and other similar societies at their principal meetings and at their section meetings are continually discussing new syllabuses and other things new and old having reference to the teaching of algebra. There is great unrest among the teachers of algebra. Out of what uneasiness of consciousness or conscience does all this disturbance come?

Moreover the dissatisfaction with present conditions isn't all ours. I remember that at a N. E. A. meeting not long ago a distinguished educationist whose interest does not lie especially in mathematics made the remark that, as things are, the benefits derived by high school students from the study of algebra do not begin to be commensurate with the time and toil devoted to the study, and he would dispense with the most of the algebra of the high school course and so save time for studies that would amount to something. There are many others of his opinion; among them many of our own pupils in algebra, both of this present time and times gone by.

It is, we know, a very frequent source of wonder among them what in the world it is all for, this manipulation of polynomial literate expressions. They multiply them, they divide them and factor them and extract their *n*th roots and raise them to the *n*th power and find their conjugates and perform a variety of other experiments vulgarly called stunts with them. They sometimes learn to play the game according to the rules pretty fairly well too and sometimes get 90 and sometimes less than 90 in regent's and other examinations. But what good has it done them? What relation does it bear to life and the actual business of life? There are very, very few of them to whom their algebra becomes a permanent intellectual interest as their history, literature, economics and natural science do become. We have to admit that algebra does not, as a matter of fact, do much for many of our pupils in any of these ways. It might. It ought to. But, as a matter of fact, it doesn't.

Well then, why cumbereth it the ground? Keep algebra in the course for those who are going on to engineering courses or higher mathematics, but for the rest dispense with it. Save time for other, more important or more fruitful studies as the educationist quoted above suggested.

Shall we consent to such an arrangement? No indeed! Not one of us or any other mathematics teacher in the Middle States and Maryland, or outside that particular Eden, will consent to anything of the sort. It may be that as a matter of fact all of our pupils are not getting all the good they should in the way of fruit from this particular fig tree, but let it be this year, till we have dug around it and till our new syllabuses are in operation and there will be a crop that will astonish the natives.

Hence the activity of our committees on new syllabus, and hence the never failing interest in papers on the subject at association meetings.

Now, as to the cause of the trouble, the reason for the failure of algebra, it lies, so we are agreed, those of us who agree that there is trouble, in the fact that, so far as the experience of many of our pupils is concerned, algebra does not have enough of bearing upon the business or interests of life. And the reason for this aloofness of algebra from life appears to be its great aloofness from life, or its extremely abstract character.

Number itself is an abstraction and the abstraction consists in the detachment of the idea of quantity from the concrete whole that includes quality as well as quantity.

Then we abstract from the idea of number everything that looks towards definiteness of abstraction and dropping that and concerning ourselves only with the indefinite abstract remainder we raise it to the *n*th power and multiply the result by the *n*th power of some other equally indefinite abstraction. Then we combine many such into polynomials and with such insubstantial material build houses of the sort not made with hands, and then we proceed to keep house in them and play games in them along with gods and archangels. And all this is great sport for us and for some of our pupils. But there is the ignobile vulgus, the common people, whom God has created in considerable numbers, who can not be quite happy unless their legs are long enough to touch the earth, and these do not find the game either interesting or edifying.

All of our committees and syllabus makers are thus diagnosing the case and are trying to remedy the trouble by making algebra more concrete.

The new Prussian Syllabus lays stress on concrete beginnings, on graphic methods, on deferring the more abstract phases of the subject, and on applications throughout to the affairs of practical life.

A commission representing eight principal learned and scientific associations of Germany which has made a report since the adoption of the new syllabus proposes a new curriculum which defers to a still later period the more abstract topics and methods, utilizes graphic methods throughout, and especially and above all insists that algebra and all mathematics are to have beginning and end and entire intervening career in connection with life and nature. Mathematics is of importance chiefly because it gives exact cognition of nature.

The report of our brethren of the Central Association, recently fulminated, thunders loud with the same thunder.

Twelve topics including the most of the complicated polynomials of algebra are expelled from the first year's work of the high school altogether. The most of the work of this year is to be problem work of a very concrete kind having its origin in well known or easily derived principles of arithmetic, geometry and physics. Multiplication and factoring are to be associated and are to lead straightway to problems involving quadratic equations and simultaneous equations. Proportion is to be taught early. Fractions, excepting such as the child may be assumed to be familiar with in connection with arithmetic, are taught late. Algebra is to be the tool of nature study. Those things that make it a useful tool for nature study are to be emphasized.

All of these proposals of reform in method and subject-matter of elementary algebra are in the same direction and they imply the reasons why it is impossible to contemplate the abandonment of algebra as an essential element of the high school curriculum.

Mathematics has been the great tool by which man has raised himself from the condition of the ignorant, impotent, superstitious wretch that he was in primæval state to that of the noble lord of creation that we see about us. And as mathematics has been in the history of civilization, the tool that has conquered the world, so it is in education the key to the interpretation of the world.

W. T. Harris' description of the field of mathematics and of the relations of its several branches to each other and to the world is useful for those of us who are teachers of elementary mathematics and who need to keep our teaching concrete and fast-rooted in the world of nature. It may be summarized as follows: Mathematics is the science of quantity and therefore the science of measurement, since measurement is the process of finding the answer to the question quantus.

If all things could be measured by the simple process of taking a unit and laying it off on the quantity to be measured, there would be no occasion for the development of such a science as mathematics. But it is impossible to measure some things that way and very inconvenient to measure other things that way. Hence mathematics has a reason for being and hence also mathematics may be defined as the general gathering of devices for performing more or less difficult jobs in measurement. The things to be measured are the extra-mental entities times, space, matter, force. There is, of course, doubt among the philosophers as to whether these things or all of them are in fact extra-mental, but they seem to be and that's enough for us.

The primary branches of mathematics are such as geometry and mechanics which formulate the principles of form and motion in accordance with which actual measurements must be made and computations carried on. The secondary or ultimate branch of mathematics is arithmetic which makes the computations and completes the measurement.

But sometimes it is impossible to get the data that geometrical or physical principles call for and the solution of our problem must be approached from indirect data. For example, geometry tells us that the area of a triangle is one half the product of base and altitude. But there is a lion in the way that prevents us from measuring the altitude. We may, however, measure the three sides. Then there must be a mighty transformation of geometric principles, a factoring and eliminating and more factoring and squaring and substituting and rationalizing of denominators and extracting of square roots and then the principle that $T = \frac{1}{2}bh$ becomes $T = \sqrt{s(s-a)(s-b)(s-c)}$.

So there is a place for an intermediate branch of mathematics between geometry and mechanics on the one side and arithmetic on the other, namely the science of the transformation of functions. This is algebra and, conversely, this is the thing that algebra is.

The subject-matter of algebra consists either of problems in which the data are the assumptions or other principles of geometry or physics, which functions must undergo more or less of transformation before numerical evaluation is possible, or it consists of chapters of development of the principles of transformation with abundant exercises, which chapters and exercises are of value only as they give the student power to perform similar transformations in the course of the solution of actual problems of measurement. If in the investigation of these principles we come to points where we catch glimpses of things below the minima or above the maxima of mundane things, imaginaries and fourth dimensions and that sort of thing, which deal not with measurement in this world but perhaps in some other, that fact rather verifies than overturns the definition of algebra given above. We at once consign those branches of the subject to the university members of our association, the people who are doing investigating off on the frontier of the science, with instructions to keep the roadway connecting our association with the world of gods and archangels well paved and in good repair. So will they earn their bread and butter while they remain with us.

(*To be continued.*)